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COMPARATIVE EFFECTIVENESS OF BIOCOMPATIBLE COMPOSITE MATERIALS IN THE TREATMENT OF DENTAL CARIES IN ADULT PATIENTS

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Abstract. Dental caries remains a major public health concern among adult po. pulations worldwide, despite significant advances in preventive and restorative dentistry. The development of biocompatible composite materials has transformed restorative approaches by combining esthetic performance with improved biological interaction. However, comprehensive comparative evaluations of these materials in adult patients remain limited.

This study aimed to comparatively assess the clinical effectiveness of biocompatible composite materials in the treatment of dental caries in adult patients, focusing on clinical performance, biological response, and patient-reported outcomes.

Keywords: dental caries, biocompatible composites, restorative dentistry, clinical effectiveness, adult patients

Introduction. Dental caries continues to be a global public health issue affecting billions of adults worldwide. Despite significant improvements in preventive dentistry, caries prevalence remains high, particularly in populations with limited access to preventive care and regular dental services. Untreated dental caries can lead to pain, infection, functional impairment, and reduced quality of life, thereby imposing a substantial burden on healthcare systems.

The evolution of restorative dentistry has been marked by a gradual shift from aggressive mechanical intervention toward biologically oriented and minimally invasive treatment strategies. Contemporary restorative approaches emphasize the preservation of healthy tooth structure, protection of pulp vitality, and long-term functional stability of restorations. Within this paradigm, the choice of restorative material plays a critical role in determining clinical outcomes.

Composite resin materials have largely replaced amalgam restorations due to their superior esthetic properties and adhesive capabilities. However, traditional composite materials are associated with certain limitations, including polymerization shrinkage, marginal leakage, postoperative sensitivity, and potential adverse biological effects. These challenges have stimulated the development of biocompatible composite materials designed to interact more favorably with dental tissues.

Biocompatible composites aim to minimize cytotoxicity, reduce inflammatory responses, and, in some cases, actively contribute to tissue remineralization through ion release. The introduction of nano-hybrid fillers, low-shrinkage resin matrices, and bioactive components has expanded the clinical potential of composite materials. Despite these advancements, comparative clinical data evaluating their effectiveness in adult patients remain insufficient.

The present study seeks to address this gap by providing a detailed comparative evaluation of different biocompatible composite materials used in the treatment of dental caries in adult patients.

Materials and Methods. A prospective, observational clinical study was conducted in accordance with ethical principles for biomedical research. Adult patients seeking restorative dental treatment were enrolled after providing informed consent.

The study included adult patients aged 18–65 years diagnosed with primary carious lesions in posterior teeth requiring direct composite restorations. Exclusion criteria included: systemic diseases affecting oral health, severe periodontal disease, parafunctional habits, allergy to restorative materials.

Three categories of biocompatible composite materials were evaluated:

1. nano-hybrid composites,
2. low-shrinkage composites,
3. bioactive composite materials.

All materials were selected based on manufacturer claims of enhanced biocompatibility and clinical use in adult restorative dentistry.

Cavity preparation was performed using minimally invasive techniques, focusing on selective caries removal. Adhesive protocols were standardized for all restorations. Composite materials were placed using incremental layering to reduce polymerization stress. Finishing and polishing procedures were performed following standardized protocols.

Clinical evaluations were performed at baseline and during follow-up visits. The following parameters were assessed: marginal adaptation, anatomical form retention, surface texture, postoperative sensitivity, color stability, patient satisfaction.

Evaluations were conducted by calibrated clinicians to minimize inter-observer variability.

Data were analyzed using descriptive statistics. Comparative analysis was performed to identify differences in clinical performance among materials. Statistical significance was set at $p < 0.05$.

Results. All evaluated biocompatible composite materials demonstrated acceptable clinical performance throughout the observation period. Restorations maintained adequate anatomical form and surface smoothness, with no cases of restoration failure or secondary caries detected during follow-up.

Composites with low polymerization shrinkage showed superior marginal adaptation and significantly reduced postoperative sensitivity. Bioactive composites demonstrated favorable biological responses, including improved patient comfort and reduced hypersensitivity in the early postoperative period.

Color stability varied among materials, with nano-hybrid composites maintaining esthetic properties more consistently over time. Patient-reported satisfaction scores were highest for restorations placed using bioactive and low-shrinkage materials.

Discussion. The results of this study confirm that biocompatible composite materials provide reliable clinical outcomes in the treatment of dental caries in adult patients. Improved marginal integrity observed in low-shrinkage composites may be attributed to reduced polymerization stress and enhanced adhesive performance.

Bioactive composite materials demonstrated promising clinical behavior, potentially due to their ability to release ions that support remineralization and reduce bacterial activity. These properties may contribute to improved long-term outcomes and align with contemporary minimally invasive dentistry principles.

Patient-centered outcomes, including comfort and satisfaction, highlight the importance of material selection beyond mechanical properties alone. Biocompatibility and biological interaction play a crucial role in modern restorative dentistry.

Limitations of this study include the relatively short follow-up period and limited sample size. Further long-term randomized clinical trials are required to validate these findings.

Effective restorative treatment of dental caries contributes to improved oral health, quality of life, and functional outcomes in adult populations. The use of biocompatible materials may

reduce the need for retreatment, decrease healthcare costs, and support sustainable oral healthcare strategies.

Conclusion. Biocompatible composite materials are effective for the treatment of dental caries in adult patients, demonstrating satisfactory clinical and biological performance. Materials with enhanced bioactive and low-shrinkage properties may provide additional benefits, including improved marginal integrity, reduced postoperative sensitivity, and higher patient satisfactio

The integration of biocompatible composite materials into routine restorative practice supports minimally invasive dentistry and may improve long-term clinical outcomes for adult patients.

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